

CLAIMS

We claim:

1. An apparatus for supporting a stage, said apparatus comprising:
 - a base;
 - 5 a platform supported from said base;
 - at least one stage configured to move about said platform;
 - a plurality of pneumatic supports configured on said base to support said platform in a first direction;
 - at least one air control valve that supplies and regulates each pressure of said
 - 10 plurality of pneumatic supports;
 - a plurality of active supports configured on said base to support said platform in said first direction; and
 - at least one amplifier that supplies and regulates the power to said active supports.
- 15 2. The apparatus of claim 1, said apparatus further comprising:
 - at least one pressure sensor that acquires data on the pressure in each said pneumatic support;
 - at least one position sensor that acquires data on the position of said platform with respect to said first direction; and
 - 20 at least one location sensor that acquires data on the location of said at least one stage with respect to said platform.
3. The apparatus of claim 1, said apparatus further comprising three said pneumatic supports and three said active supports, each said pneumatic support being positionally
- 25 paired with one said active support.
4. The apparatus of claim 2, said apparatus further comprising a control system comprising a processor and a computer program product containing a model that produces a target pressure for each said pneumatic support and instructions for:
 - 30 receiving said data from said pressure, position, and location sensors;
 - producing target pressures for each said pneumatic support using said model and said stage location data;
 - comparing said target pressures to said acquired pressure data;
 - controlling said valve to change said acquired pressures so that said acquired
 - 35 pressures move toward said target pressures;

comparing said platform position data to a desired platform position; and
controlling said amplifiers to change said power to said active supports so that said
acquired platform position moves toward said desired platform position.

- 5 5. The apparatus of claim 4, wherein said model comprises a matrix of a plurality of
predetermined stage locations with a corresponding target pressure for each said pneumatic
support at each said stage location and wherein said using said model comprises:

inputting said stage location data from said location sensors;
finding said predetermined location that is nearest to said input location; and
10 producing said target pressures corresponding to said nearest location.

6. The apparatus of claim 4, wherein said model comprises an equation with said
equation producing said target pressures in response to an input stage location and said
using said model comprises:

15 inputting said stage location data from said location sensors;
solving said equation; and
producing said target pressures from said solution.

7. The apparatus of claim 4 wherein said target pressures cause said pneumatic
20 supports to support the majority of the weight of said platform and said stage.

8. An apparatus for supporting a stage, said apparatus comprising:
a base;
a platform supported from said base;
25 at least one stage configured to move about said platform;
a plurality of pneumatic supports configured on said base to support said platform in
a first direction;
pressure control means for supplying and regulating each pressure of said plurality
of pneumatic supports;
30 a plurality of active supports configured on said base to support said platform in said
first direction; and
power control means for supplying and regulating the power to said active supports.

9. The apparatus of claim 1 wherein the number of pneumatic supports is the same as
35 the number of active supports.

10. The apparatus of claim 2, said sensors comprising at least one interferometer.

11. The apparatus of claim 2, said sensor comprising at least on encoder.

5 12. The apparatus of claim 1, said apparatus further comprising control elements for controlling the location of said at least one stage on said platform.

13. A control system for controlling an apparatus for supporting a stage, said apparatus comprising a base from which a plurality of pneumatic supports and active supports support
10 a platform which in turn supports said stage and sensors for sensing pneumatic support pressure, platform position, and stage location, said control system comprising:

a processor; and

a computer program product containing:

15 a model that produces a target pressure for each said pneumatic support; and instructions for:

receiving data from pneumatic support pressure, platform position, and stage location sensors;

producing target pressures for each pneumatic supports using said model and said stage location data;

20 comparing said target pressures to said received pressure data; controlling valves to change said pressures so that said received pressures move toward said target pressures;

comparing said received platform position data to a desired platform position; and

25 controlling amplifiers to change power to said active supports so that said acquired platform position data moves toward said desired platform position.

14. The apparatus of claim 13 wherein said target pressures cause said pneumatic
30 supports to support the majority of the weight of said platform and said stage.

15. A method for supporting and vibrationally isolating a platform, the platform itself supporting at least one stage, the method comprising:

supporting a platform from a base using a plurality of pneumatic supports and a plurality of active supports, said platform itself supporting at least one stage and said platform having a desired position;

modeling said pneumatic supports, said model providing target pressures for each
5 said pneumatic support for an input stage location;
moving said at least one stage about said platform during a process;
adjusting said pneumatic supports to said target pressures;
determining said platform position;
regulating said active supports to move said platform toward said desired platform
10 position.

16. The method of claim 15 wherein said target pressures cause said pneumatic supports to support the majority of the weight of said platform and said stage.

15 17. The method of claim 15, said supporting step using three pneumatic supports and three active supports.

18. The method of claim 15, wherein said process is a lithography process.

20 19. The method of claim 15, wherein said desired platform position is substantially level.

20. The method of claim 15, said modeling comprising locating said at least one stage at a plurality of locations on said platform and determining a target pressure for each said
25 pneumatic support for each said location; and said determining a target pressure for each said pneumatic support comprising:

comparing the position of said platform to said desired platform position;
adjusting said pressure at each said pneumatic support until said platform position attains said desired platform position;
30 designating said adjusted pressures as said target pressures for each said pneumatic support for said stage location.

21. The method of claim 20, said modeling further comprising:
determining target pressures at a plurality of stage locations along a first line of
35 potential stage travel;

determining target pressures at a plurality of stage locations along a second line of potential stage travel;

combining said target pressures at locations along said first line with said target pressures at locations along said second line to create said model for the entirety of said platform surface traveled by said stage, said first and second directions being approximately orthogonal to one another.

22. The method of claim 20, said modeling further comprising creating a matrix of said target pressures corresponding to each said stage location.

23. The method of claim 20, said modeling further comprising creating an equation from said target pressures and corresponding stage locations, said equation having a gain.

24. The method of claim 20, said modeling further comprising creating both an equation and an associated matrix from said target pressures and corresponding stage locations, said equation having a gain.

25. The method of claim 24, said modeling further comprising a rough tuning step and a fine tuning step, said rough tuning step comprising:

moving said stage to a plurality of locations on said platform;
adjusting said pressure of each said pneumatic support until said platform is near said desired platform position for each said stage location;
recording said resulting pressures for said stage location; and

said fine tuning comprises:

moving said stage to a plurality of locations on said platform
regulating said active supports to force said platform to said desired platform position at each said stage location;

monitoring a voltage of each said active support, said voltage indicating the amount of force being exerted by said active support;

adjusting said pressures to force said voltages towards a desired voltage; and

recording said adjusted pressure as said target pressure for each said pneumatic support at said stage location.

26. The method of claim 24, said modeling further comprising creating a rough equation from said target pressures and corresponding stage locations after said rough tuning, said rough equation having a gain, and an alternate fine tuning step comprising:

regulating said active supports to force said platform to said desired platform
5 position based on said rough equation;
monitoring a voltage of each said active support, said voltage indicating the amount of force being exerted by said active support;
adjusting said gain to force said voltages towards a desired voltage; and
designating said rough equation with said adjusted gain as said model.

10

27. The method of claim 24, said modeling further comprising creating both a rough matrix and a rough equation from said target pressures and corresponding stage locations after said rough tuning, said rough equation having a gain, and an alternate fine tuning step, said alternate fine tuning step comprising:

15 regulating said active supports to force said platform to said desired platform position based on said rough equation;
monitoring a voltage of each said active support, said voltage indicating the amount of force being exerted by said active support;
adjusting either or both of said gain and said target pressure value of said matrix to
20 force said voltages towards a desired voltage; and
designating the combination of said rough equation with said adjusted gain and said matrix with said adjusted target pressures as said model.

28. The method of claim 24, said rough tuning comprising:

25 moving said at least one stage to a location on said platform;
adjusting said pressure at each said pneumatic support until said platform is near said desired platform position; and
recording said resulting pressures for each said stage location; and
said fine tuning comprising:
30 moving said at least one stage to a location on said platform, said location being one of the plurality of stage locations from said rough tuning;
controlling said pressures of said pneumatic supports towards said resulting pressures for said stage location;
regulating said active supports to force said platform to said desired
35 platform position;

monitoring a voltage of each said active support;
adjusting said gain to force said voltages to a desired voltage; and
incorporating said adjusted gain into said model.

- 5 29. The method of claim 28, said rough tuning further comprising:
equipping said base with at least one hardstop to limit the travel of said platform;
and said adjusting step comprising manual adjustments of said pressure until said base is
not contacting said at least one hardstop.
- 10 30. A method for positioning and vibrationally isolating a platform and at least one stage
in a process, said method comprising:
designating a desired platform position;
supporting said platform and stage primarily with a plurality of pneumatic supports
from a base;
15 further supporting said platform and stage with a plurality of active supports;
moving said stage about said platform in a process;
determining the location of said stage as said stage is moved about said platform;
inputting said determined stage location into a model, said model providing a target
pressure for each said pneumatic support based on said stage location;
20 adjusting said pneumatic support pressures to said target pressures;
comparing platform position after said adjusting step to said desired platform
position; and
controlling said active supports to move said platform closer to said desired platform
position.
- 25 31. The apparatus of claim 30 wherein said target pressures cause said pneumatic
supports to support the majority of the weight of said platform and said stage.
- 30 32. The method of claim 30, said process comprising a lithography process.
33. The method of claim 30, wherein said model creation comprises:
moving said at least one stage about the surface of said platform to a plurality of
fixed locations;
adjusting said pneumatic support pressures so that said platform is at said desired
35 position when said at least one stage is at each said fixed location;

recording the pressure after each said adjustment;
creating a matrix of said recorded pneumatic support pressures and said fixed
locations;

fine tuning said matrix, said fine tuning comprising:

- 5 monitoring said pressure of said pneumatic supports;
 monitoring a voltage of said active supports;
 monitoring said at least one stage location;
 moving said at least one stage about the surface of said platform to said
 plurality of fixed locations and adjusting said pressures to new values to drive said
10 voltages towards a desired voltage; and
 revising said matrix with said new values.

34. An exposure apparatus including the apparatus of claim 1.

15 35. A device manufactured with the exposure apparatus of claim 34.

36. A wafer on which an image has been formed by the exposure apparatus of claim 34.

37. A method of making a wafer utilizing the method of claim 18.

20 38. A method of making a device utilizing the method of claim 18.

39. A method of making a wafer utilizing the method of claim 32.

25 40. A method of making a device utilizing the method of claim 32.

41. A stage device comprising:
 a platform;
 at least one stage supported by the platform, said at least one stage being movable
30 relative to said platform;
 at least one pneumatic support that supports said platform in a predetermined
 direction;

 at least one active support connected to said platform, said at least one active
support generating force that acts on the platform in said predetermined direction; and
35

a control system connected to said at least one pneumatic support and said at least one active support, said control system including a first control loop and a second control loop, wherein said first control loop controls said active support based on information related to position of said platform and said second control loop controls said at least one pneumatic support based on a position of said at least one stage independently from said information of said position of said platform.

42. The stage device of claim 41, further comprising a sensor that acquires data related to the pressure of said at least one pneumatic support, and wherein said first control loop controls said active support based on a relationship between a target pressure of said at least one pneumatic support and said data detected by said sensor.

43. An exposure apparatus including the stage device of claim 41.

44. A device manufactured with the exposure apparatus of claim 43.

45. A wafer on which an image has been formed by the exposure apparatus of claim 43.